The Intensity JND Comes From Poisson Neural Noise: Implications for Image Coding

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Abstract: While the problems of image coding and audio coding have frequently been assumed to have similarities, specific sets of relationships have remained vague. One area where there should be a meaningful comparison is with central masking noise estimates, which are important in coding. In the past few years, progress has been made on this problem in the auditory domain (Allen and Neely, J. Acoust. Soc. Am., **102**, 1997, 3628-46; Allen, 1999, Wiley Encyclopedia of Electrical and Electronics Engineering, Vol. 17, p. 422-437, Ed. Webster, J.G., John Wiley & Sons, Inc, NY). It is possible that some useful insights might now be obtained by comparing the auditory and visual cases. In the auditory case we have shown, directly from psychophysical data, that the square of the loudness JND $[\Delta\mathcal{L}(\mathcal{L})]^2 \propto \sigma_{\mathcal{L}}^2$ (i.e., the loudness variance) is proportional to the loudness $\mathcal{L}(I)$ below about 5 sones (a measure of loudness, a unit of psychological intensity). This is true for both wideband noise and tones, having a frequency of 250 Hz or greater. Thus the masking noise appears to be Poisson (i.e., neural point process noise). It follows directly that the Weber fraction (the relative loudness JND), decreases as one over the square root of the loudness, namely

$$\Delta\mathcal{L}/\mathcal{L} \approx 1/\sqrt{\mathcal{L}}.$$

Above $\mathcal{L} = 5$ sones, the relative loudness JND $\Delta\mathcal{L}/\mathcal{L}$ becomes 0.02, a constant independent of the loudness. It would be very interesting to know if this same relationship holds for the visual case between brightness and the brightness JND. This might be tested by measureing the contrast JND of a Gabor wavelet as a function of intensity, and transforming the JND into a brightness JND via the function by

$$\Delta\mathcal{B}(I) = \Delta I \frac{d\mathcal{B}}{dI}.$$

If the Poisson nature of the loudness relation (below 5 sones) is a general result of central neural noise, as is anticipated, then we would expect that it would also hold in vision, namely that $\Delta\mathcal{B}(\mathcal{B}) \propto \sqrt{\mathcal{B}(I)}$.